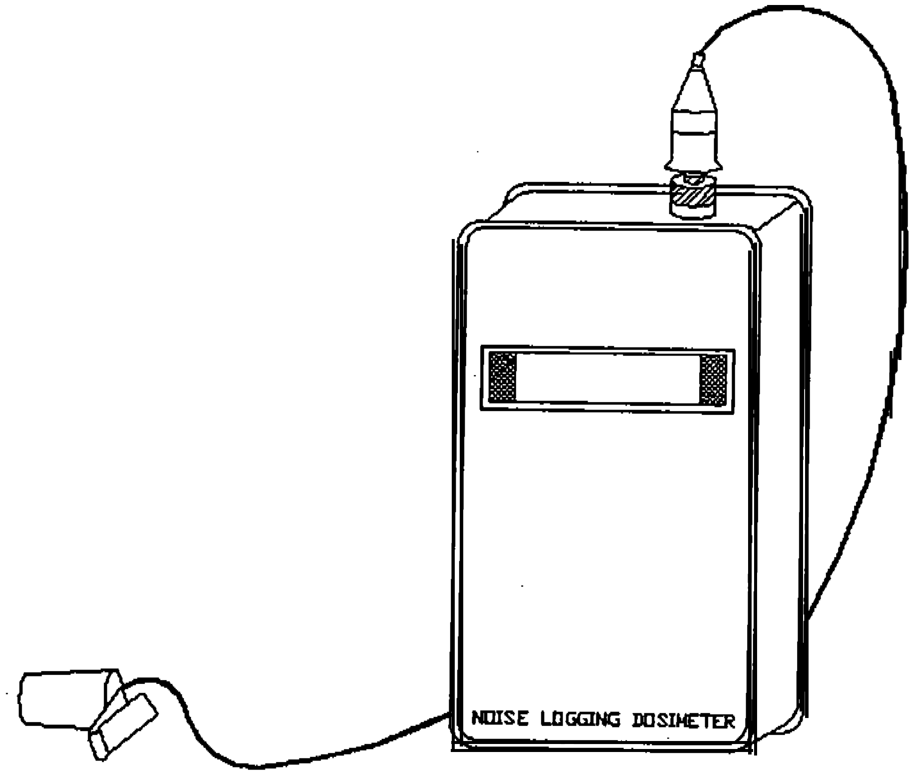
TG 181

Noise Dosimetry and Risk Assessment



U.S. Army Environmental Hygiene Agency
Bio-Acoustics Division and Industrial Hygiene Field Services Program
Aberdeen Proving Ground, **Maryland 2101** *0-5422*

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NOISE DOSIMETRY AND RISK ASSESSMENT

CHAPTER 1: Introduction

1-1. Purpose and Scope

a. This Technical Guide (TG) describes methods for determining the S-hour time-weighted average sound level (TWA). The TWA is needed to identify noise hazardous operations so that personnel performing these operations can be:

(1) Enrolled in the U.S. Army Hearing Conservation Program.

(2) Notified of their hazardous noise exposure level.

b. The procedures in this TG are applicable to civilian employees of the U.S. Army and soldiers working in industrial-type operations. This TG is not applicable to soldiers performing military-unique activities such as training exercises.

c. The primary method of determining the TWA is measurement using noise dosimeters,

d. The **TWA** is used to quantify hazards from steady-state noise in the audible range up to 16,000 hertz (Hz). The TWA is not used to quantify hazards from impulse noise or from airborne high frequency (ultrasonic noise). Refer to Appendix B for a discussion and applicability of noise hazard criteria.

1-2. Regulatory Foundation

The U.S. Army Hearing Conservation Program requires that installations:

a. Enroll all Army personnel routinely exposed to hazardous noise in a hearing conservation program. Consider personnel routinely exposed to a TWA of 85 decibels, A-weighted (dBA) or greater as exposed to hazardous steady-state noise.

b. Survey all suspected noise hazardous operations at least once but also within 30 days of a change in operation that results in a change in the TWA.

c. Determine the TWA for each civilian employee upon the employee's assignment to a noise-hazardous operation and within 30 days of a change in assignment or operation that results in a change in the TWA. Make the determination either by calculations based on previous data or by new measurements.

d. Comply with the hazard notification requirements of the Occupational Safety and Health Administration (OSHA). The OSHA requires that the employer (in this case the U.S. Army) notify all civilian employees working in noise hazardous operations of the TWA to which they are routinely exposed. The U.S. Army Medical Department (AMEDD) has extended this requirement to include soldiers working in industrial-type operations.

e. Assign a risk assessment code (RAC) to each noise-hazardous operation.

f. Enter noise hazard information into the Health Hazard Information Module (HHIM) database of the Occupational Health Management Information System (OHMIS).

1-3. Key Terms and Abbreviations

The glossary defines the abbreviations and technical terms used throughout this document. However, three key terms, defmed below, are inherent to understanding the methods for determining TWAs and RACs.

a. The 8-hour Time-Weighted Average Sound Level (TWA).

(1) The TWA is a measure of the severity of the employee's workday noise environment.

(2) The TWA is an expression of the constant noise level, measured in dBA, which can potentially produce the same hearing damage over an 8-hour period as the actual workday noise exposure.

(3) The TWA is always computed as if the TWA noise level is present for an 8-hour work shift.

(4) Because the TWA is a measure of the noise environment, it <u>does not</u> reflect the effects of any hearing protection worn by employees.

b. Noise Dose. The noise dose (*D*) is the ratio, expressed as a percentage, of the damage potential of a noise environment to the damage potential of exposure to 85 dBA for 8 hours.

c. Time-Intensity Exchange Rate. The time-intensity exchange rate is the change in the level of sound required to double the damage potential of the sound during a fixed time period of exposure. For U.S. Army hearing conservation, the exchange rate is 3 decibels (dB). This exchange rate is implicit in the TWA and noise dose. **Note that the U.S. Army** has recently adopted the 3 dB exchange rate. Previously, the Army used a 4 dB exchange rate. The OSHA uses 5 dB.

1-4. Technical Assistance

a. Obtain technical advice by telephone from the following U.S. Army Environmental Hygiene Agency points of contact:

(1) Industrial Hygiene Division, DSN 584-3118, Commercial (410) 671-3118.
e-mail: hshbmiw@aeha1 .apgea.army.mil

(2) Bio-Acoustics Division, DSN 584-3797, Commercial (410) 671-3797.
e-mail: hshbmob@aeha1.apgea.army.mil

b. Direct requests for services through appropriate command channels of the requesting activity to:

Commander
U. S . Army Environmental Hygiene Agency, Industrial Hygiene Division
ATTN: HSHB-MI-W
Aberdeen Proving Ground, MD 21010-5422

Commander
U.S. Army Environmental Hygiene Agency, Bio-Acoustic Division
ATTN: HSHB-MO-B
Aberdeen Proving Ground, MD 21010-5422

1-5. When to Quantify the TWA

a. The need for determining the TWA will be based on the potential for significant noise exposure among a population of employees. Industrial hygienists must use professional judgment to identify operations having a potential for significant noise exposure.

b. The industrial hygienists will determine TWAs at least once and again within 30 days of any significant change in production, process, or control measures that could result in a change in noise exposure. Factors which may be used in these determinations can include:

(1) Suspected noise hazard. A good rule is to suspect a steady-state noise hazard when individuals have to raise their voice levels to be understood at 1 meter.

(2) Sound level meter (SLM) readings.

(3) Employee complaints.

(4) Previous dosimetry measurements.

(5) Process changes, new equipment, etc., that could be considered noisy.

CHAPTER 2: Instumentation for Determining the TWA

2-1. Methods of TWA Quantification

a. The primary method of quantifying the TWA is measurement with a personal noise dosimeter.

b. The TWA can also be calculated using measurements from a hand-held SLM. The SLM method, described in Appendix C, is not very practical because it is very time-consuming.

2-2. The Noise Dosimeter

a. The noise dosimeter consists of a microphone section and a logger section. The microphone section is usually connected to the logger section by a cable.

(1) The microphone section senses the sound pressure in the wearer's hearing zone and converts the pressure to an electrical signal.

(2) The logger section processes the electrical signal, computes the dB levels and other parameters, stores the information, and provides a readout. The readout is usually a liquid crystal display (LCD) on the logger unit, and many dosimeters have downloading capability to a computer or printer.

b. Through a competitive bid process, the U.S. Army has procured hits of Quest model M-28D noise dosimeters.

(1) Quest M-28D dosimeter kits were issued to U.S. Army Medical Department Activities (MEDDACs) having Industrial Hygiene (IH) sections.

(2) Each kit consisted of Quest M-28D dosimeters, a Quest CA-12B acoustic calibrator, a printer, associated interconnection cables, and computer software.

(3) The dosimeter-related discussion in the main body of this TG assumes that a Quest M-28D dosimeter kit is used.

(4) Quest M-28D dosimeters were not issued to Army National Guard activities. Also, many IH groups in the Army have other dosimeter models. Refer to Appendix D for a general discussion of dosimeters, Army dosimeter requirements, and an outline of the steps required to configure any qualifying dosimeter for Army use.

2-3. Setting the Quest M-28D Noise Dosimeter

a. The Quest M-28D Noise Dosimeters were configured at the factory according to the contractual requirements. Army requirements changed since the delivery of dosimeters was completed. Therefore, the settings must be changed before the M-28D can be used for Army hearing conservation purposes.

b. The settings of the M-28D are controlled by three slide switches located inside the battery compartment of the dosimeter. Each slide switch has eight on-off positions.

c. To change the setting on the M-28D:

(1) Access the switches according to the instruction manual.

(2) Set switches 1 and 2 as indicated in Table 2-l and illustrated in Figure 2-l. Some switch settings are mandatory for the U.S. Army Hearing Conservation Program; these are annotated as "mandatory" in Table 2-1. All other settings arc optional, but the settings annotated as "recommended" are useful.

(3) Switch 3 settings are associated only with the printer and computer interfaces and do not influence the noise measurement process. Switch 3 does not require resetting to accommodate the changes in Army requirements.

2-4. Calibration Requirements

a. Acoustically verify the calibration of the dosimeter (to within +/- 1 dB) before and after use on the day the measurements arc collected. Verify calibration using the acoustical calibrator provided with the dosimeter kit.

b. Calibrate the acoustic calibrator at least annually according to the manufacturer's instructions.

c. Current Army calibration policy considers the dosimeter to be a digital device and annual calibration is not required. This policy may change.

2-5. Dosimeters as Sound Level Meters. The Quest M-28D and many other dosimeters also meet the requirements of American National Standards Institute (ANSI) S1.4-1983 for type S2A SLMs. This qualifies their use as noise survey SLMs for Army hearing conservation purposes.

Table 2-l. Switch Setting for the Quest M-28D Dosimeter.

Switch 1

Position	Setting	Requirement	Explanation
1	Off	Mandatory	Off = A-weighting
2	Off	Mandatory	Off = 50 dB range
3	Off	Recommended	Off = 115 dB upper limit
4	Off	Mandatory	Off = Slow response
5	On	Mandatory	On-Off = 85 dBA criterion level
6	Off	Mandatory	
7	Off	Mandatory	Off-Off = 3 dB exchange rate
8	Off	Mandatory	

Switch 2

Position	Setting	Requirement	Explanation
1	Off	Mandatory	Off = either 80 dB or no threshold
2	Off	Mandatory	Off = no threshold
3	Not used		On or Off has no effect
4	Off	Recommended	off = Ldn off
5	On	Optional	On = 24-hour clock
6	Off	Optional	Off = l-minute histogram
7	On	Recommended	On = Max level displayed on histogram
8	On	Recommended	On = Peak level displayed on histogram

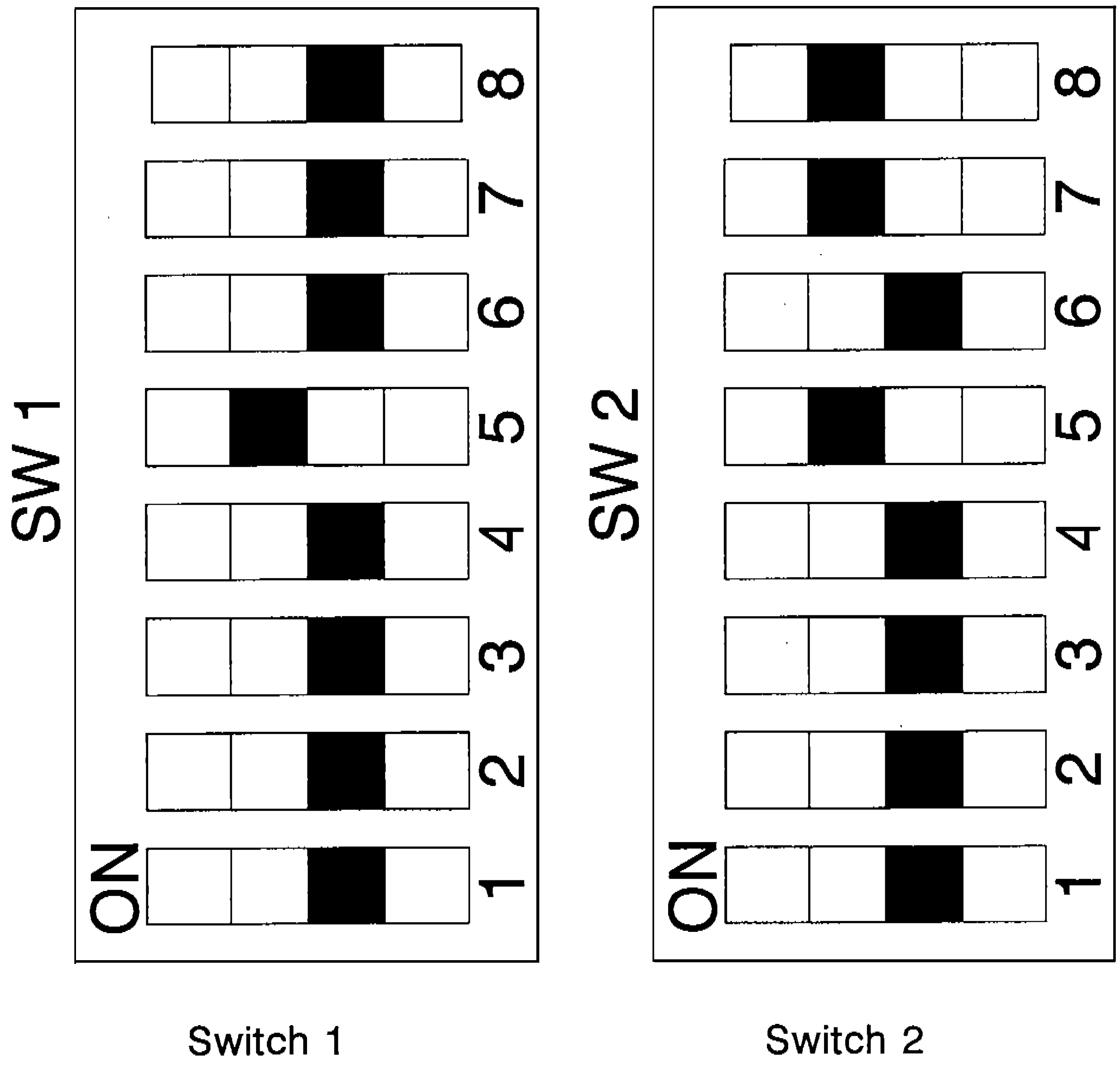

Figure 2-1. Switch settings.

2-6. Peculiarities of the Quest M-28D

The Quest M-28D has the following peculiarities:

a. Uses "histogram" to refer to the time history.

b. Uses the equivalent sound level ("LEQ") key to read out the average sound level (Lavg) on the LCD.

c. Uses the "EVENT" key to read out the projected dose on the LCD.

d. Uses the sound exposure level ("SEL") key to read out the TWA on the LCD. (Note: SEL is not the same as the TWA; however, on the Quest M-28D dosimeter pressing the "SEL" key gets the TWA reading.)

CHAPTER 3: The Sampling Strategy

3-l. General Considerations

a. This chapter provides guidelines for devising a sampling strategy to obtain a TWA that is reasonably accurate and cost effective. The sampling strategy defmes the sample size (number of individuals who will wear the dosimeter), the measurement duration (the times during which the dosimeter will be worn), and the number of noise measurement repetitions.

b. The U.S. Army Hearing Conservation Program requires that any population suspected of working in or at a noise-hazardous operation be assessed to determine the noise exposure in terms of its TWA. Obviously, performing personal noise dosimetry for several weeks on everyone working in a suspected hazardous noise area would produce a very accurate characterization of the TWA exposure. However, this would be cost prohibitive in terms of both equipment and personnel. The sampling strategy aims to consolidate the dosimetry effort by measuring only a representative number of personnel for a representative time duration.

c. When performing assessments, the noise exposure results for the population can be divided into three groups:

a (1) Group 1 - All members routinely exposed to a TWA at or over 85 dBA.

(2) Group 2 - AU members consistently exposed to a TWA below 85 dBA.

(3) Group 3 - The members' TWA exposures vary above and below 85 dBA over the course of the month or week. Determining if the true TWA is above or below 85 dBA is difficult.

d. Sampling to determine if an employee is a member of group 1 or 2 is not difficult; simply pick any day of the week and sample. However, if the employee is a member of group 3, it will be more difficult to determine if the TWA is below 85 dBA. The difficulty in determining group 3 noise exposures is caused by not knowing if the sample taken is truly representative of the employee's exposure. The sampling strategy in this chapter is intended to reduce this difficulty.

e. There arc no regulatory requirements detailing the structure of a sampling strategy for noise exposure. This chapter provides some recommended guidelines, but ultimately, the sampling strategy must be based on the professional judgment of those individuals, usually industrial hygienists who are responsible for obtaining the TWA.

f. The recommended overall objective of the sampling strategy is to be 75 percent certain that all employees with more than a 10 percent chance of being routinely exposed to a TWA of 85 dBA and higher are enrolled in the hearing conservation program. In statistical terms, the recommended objective is to identify the 90th-percentile rank of the TWA distribution with at least 75-percent confidence. This is a recommended minimum.

3-2. Initial Noise Evaluation

a. The first step in defining the sample size and measurement durations is to obtain information on the work operations and the approximate level of the noise in the suspected hazard area. To obtain this information:

(1) Talk to employees and their supervisors to understand the work routines in the suspected hazardous operation. Observe the work processes. Note the variability over the workday or workdays. Note predictability, particularly with respect to the noise level.

(2) Gain an understanding of the characteristics of the noise environment by conducting a preliminary noise survey (usually with an SLM or a dosimeter in the SLM mode of operation). Note the noise levels generated and their time durations. If possible, calculate a rough estimate of the TWA using some of the procedures in Appendix C. The character of the noise environment influences TWA and has implications for the sampling strategy.

b. Types of noise exposure patterns:

(1) Situations in which the noise level is constant over the entire range of travel of the group are rare. Such a noise environment can exist if the noise sources arc remote from personnel locations and are evenly distributed over the range of travel. Area noise monitoring is adequate for such situations, and personal dosimetry is not required. If the noise level also does not vary with time, then a dosimeter is not required, and the sampling strategy can consist of a single measurement with an SLM.

(2) More common are situations in which noise sources, such as noisy machines, are accessible to the employees. In a typical machining operation the noise level can be high at the operator position but can drop off markedly with distance from the machine. Personal noise dosimetry is the only practical method of defming the TWA in this case.

3-3. Grouping

a. Group employees according to similar noise exposure. The objective is to defme groups for which random sampling is a statistically valid approach to estimating the TWA of all the members of the group.

(1) Noise exposure is made up of predictable and unpredictable factors. After the initial noise evaluation, the noise exposure will vary predictably according to specific factors. These factors are the controlled variables. The noise exposure will also vary unpredictably. Unpredictable variations can be considered as the uncontrolled variables.

(2) Random sampling is statistically valid when groups are defined according to similarity of controlled variables. This leaves the random sampling only for the uncontrolled variables.

(a) Example A - The 46 employees in the grinding branch are divided into two sections. Section 1 contains 14 employees who perform centerless grinding. Section 2 contains 32 employees who perform flat grinding. The centerless grinding machines are much louder than the flat grinding machines. The two controlled variables with respect to noise exposure are grinding and the type of grinding machine (flat or centerless). The uncontrolled variable is the amount of work assigned to each employee. The grinding branch should be broken up into two groups for sampling: centerless grinding and flat grinding.

(b) Example B - After a reorganization, the 46 employees in the above grinding branch are divided into two sections. Section 1 contains 23 employees who perform grinding on the day shift. Section 2 contains 23 employees who perform grinding on the night shift. All employees perform both centerless and flat grinding and arc assigned work as it comes in. Here the type of grinding is no longer a controlled variable. For sampling purposes, the group is now the entire grinding branch (46 employees).

b. Usually, grouping tends to follow organizational lines, but there may be cases where exposure similarity falls across organizational lines. There is no reason to sample each branch or team if the noise exposure is similar to the exposure for a group already sampled.

c. Random sampling may not always be the most desirable approach. An example is a maintenance group that performs very noisy operations (TWA > 100 dBA) only a few days per year, with quiet work the rest of the time. Random sampling would be difficult for this group because of the extreme variability of the noise exposure. Nonrandom sampling based on judgment would be more appropriate. A 10 percent probability of exposure to a TWA of 85 dBA is equivalent to just over 2 days per month of exposure. In this case, dosimetry could be performed only on the noisy days, and if the operation is performed by each employee an average of 2 days per month or more, the group would be included in the hearing conservation program. If the operation is performed less than 2 days per month, then the probability of exposure is less than 10 percent, and the employees would not be included in the hearing conservation program.

3-4. Sample Duration and Population

a. An individual sample value consists of a TWA measurement which has been obtained by placing the dosimeter on an employee for a certain duration. It is usually considered good IH practice to measure over the entire work shift or close to it. However, other durations may be appropriate under certain circumstances. For example, if the noise exposure is relatively constant over the duration, a duration shorter than the entire work shift will produce valid data with a reduced cost in IH time. However, using a duration different from the work shift duration requires some additional computations. Appendix E discusses varying measurement durations.

b. Each duration for each employee in the group constitutes a separate potential sample value. If the group has 10 members and the sample duration is an 8-hour work shift, then on each new day there are 10 new potential sample values. Over a year, the total population from which to sample would be over 2,000 sample values.

3-5. Selecting Employees and Days for Measurement

a. Since the sample TWA values should be representative of the population, any known conditions that result in unrepresentative values should be avoided. Examples of conditions to avoid include:

(1) Certain days of the week. Many sampling plans recommend avoiding Mondays and Fridays.

(2) All samples on one day. If the work flow varies from day to day, the sampling should be spread out over many days.

b. The optimum number of samples required depends on the variability of the data, the cost of sampling, the cost of the consequences of the results, the percentile to be identified and the desired confidence level. Some of these variables are unknown and can only be estimated after the sampling begins. A recommended starting point is to select a sample size of five and analyze the data. Base the need for further sampling on the results.

c. Select employees at random from the group using the following procedure:

(1) Determine the number of workers (n) from the group (N) to sample on a given day.

(2) Assign each individual in the risk group a number from 1 to N, where N is the number of people in the group.

(3) Arbitrarily choose a starting position in Table 3-1. Read down, ignoring numbers greater than N as well as the number zero, and select the numbers less than or equal to N. Continue selecting numbers this way until __n__ numbers have been chosen. If necessary, proceed to the next column, and if at the bottom of the last column, proceed to the top of column 1. Perform dosimetry measurements on the individuals from group N with the corresponding number assignment.

Table 3-1. Table of Random Numbers for Selecting Individuals for Sampling.

21	90	47	3	94	8	2	36	25	50	98	9
55	48	69	22	58	32	57	58	72	51	50	62
43	15	44	47	11	69	36	32	1	88	34	95
59	95	0	61	96	8	11	2	71	10	50	79
88	44	18	91	25	33	75	67	3	28	4	64
67	75	97	9	82	10	76	48	64	83	22	38
31	0	49	48	55	95	87	93	70	24	98	93
96	86	13	59	88	71	2	92	17	24	54	26
66	46	0	78	65	12	46	36	32	16	39	62
59	43	58	30	8	63	24	80	39	51	42	3
62	33	66	46	14	57	84	50	58	86	35	1
13	22	50	18	4	47	10	60	37	96	41	56
4	53	25	67	6	68	41	65	7	6	25	42
10	15	65	45	59	22	10	31	62	55	12	51
48	83	89	57	41	94	14	37	61	83	30	70
50	77	86	10	27	79	6	95	61	38	75	78
73	44	51	85	65	51	10	0	69	16	5	69
25	77	56	38	83	44	65	4	25	19	57	4
25	43	38	20	17	67	92	13	3	43	88	78
75	50	23	31	70	35	85	12	43	87	44	24
72	27	60	85	84	35	31	13	4	90	49	35
33	42	95	17	53	9	48	26	46	93	28	9
53	32	59	2	46	63	56	62	32	23	42	29
79	66	87	2	67	9	67	53	62	5	61	56
24	32	59	45	30	21	4	1	21	97	53	53
88	47	71	17	67	22	40	51	65	52	2	37
17	92	20	91	56	95	70	94	22	4	51	50
80	75	29	71	79	20	97	82	23	79	67	55
78	15	82	68	94	33	55	84	57	29	36	65
70	54	98	97	48	15	50	57	50	95	80	86
28	92	18	4	3	0	22	41	70	92	95	94
18	51	25	8	91	10	44	89	55	21	24	32
6	56	84	81	93	21	36	10	72	5	44	35
82	50	13	41	44	44	8	45	93	46	88	75
22	26	71	80	66	39	26	63	98	17	83	38
62	95	76	10	15	48	4	90	12	69	20	20
6	62	50	37	69	59	23	50	52	68	45	54
54	46	82	57	29	89	74	43	9	56	77	52
59	12	25	85	48	0	21	45	57	36	47	85
1	29	9	99	85	27	96	25	74	85	71	79
1	63	85	14	89	46	17	0	7	88	36	36
41	82	92	80	0	57	29	6	42	99	23	88
24	93	50	10	79	95	70	94	17	29	44	63
55	5	75	21	63	66	65	59	45	55	13	92
40	16	23	14	45	8	44	82	72	56	36	24
21	17	58	69	81	78	80	9	58	74	28	80
29	37	40	68	13	61	62	45	78	2	58	26
63	97	49	47	33	7	82	82	54	92	12	68
95	0	21	66	53	94	55	42	9	92	90	80
99	40	17	7	18	8	61	56	49	7	18	49

CHAPTER 4: Dosimetry Protocol

4-l. Advance Coordination with Managers and Supervisors

Coordinate the dosimetry sampling schedule with managers, supervisors and local union representatives. Inform supervisors which employees will wear the dosimeter and for how long.

4-2. Coordination with Employees

a. Explain the purpose of the measurement to the employees. Inform employees that the dosimeter should not hamper normal duties and request that work be performed in the usual manner.

b. Assure employees that the dosimeter is strictly a device that numerically quantifies noise exposure and is not capable of recording conversation so they know their privacy will not be compromised.

c. Instruct employees about the proper wearing of the dosimeter.

d. Require that the dosimeter be worn until it is collected and the microphone remain exposed and unobstructed by clothing or outer garments.

e. Inform employees to surrender the dosimeter when leaving the work premises for non-duty purposes.

f. Inform employees who resist the wearing of noise dosimeters that personal noise exposure monitoring is an essential element of their Occupational Safety and Health (OSH) Program. The Occupational Safety and Health Act [Section 5(b)] and most labor contracts require employees to participate in management's safety and health programs. Consult with your local Judge Advocate's Office to get a legal opinion regarding the effect of contracts and bargaining agreements on wearing of dosimeters.

4-3. Pre-calibration Check

On the day of the measurement, prior to obtaining the measurement--

a. Check the battery.

b. Use the acoustical calibrator to verify that the calibration is within +/- 1 dB of the requirement. Adjust the dosimeter sensitivity if necessary.

4-4. Attaching the Dosimeter

a. Usually you will clip the logger portion of the dosimeter to the belt or the waistband or place it in the shirt pocket. Have extra belts available for employees who do not wear belts. Clip the microphone on the shirt collar at the shoulder closest to the dominant noise source. If a collar is not available, place the microphone at the top of the shoulder on the outer garment no more than 6 inches away from the worker's ear. Orient the microphone in accordance with the manufacturers instructions.

b. Ensure that the microphone cable is routed so that it cannot snag or obstruct the wearer's work. Use tape to fasten the cable if necessary. This is an important safety issue.

c. Place the windscreen over the microphone.

4-5. Obtaining the Measurement

a. Set the dosimeter to the "run" mode.

b. Attach the logger face cover.

c. If possible, observe the employee throughout the work shift. At an absolute minimum, check the employee at various times during the work shift to ensure that the dosimeter is in place, oriented properly, and not subjected to unusual or improper noise. Periodically measure the noise level at the worker's ear with an SLM.

d. At the end of the measurement duration, recover the dosirneter, remove the face cover, set the dosimeter to pause, and recheck the calibration. If the calibration is not within +/- 1 dB of requirements, discard the data and repeat the measurement.

4-6. Recording the Measurement Data

The data may be printed out, dumped into a microcomputer (PC), or manually transcribed. There are no established format requirements. As a minimum, record the following information [the items marked with an asterisk (*) are printed or dumped into the PC by the Quest M-28D]:

a. The make, model, and serial number of the dosimeter.

b. The serial number and last annual calibration date of the acoustic calibrator.

c. The pre- and post-calibmtion verification dates and levels.

d. The name and social security number of the employee wearing the dosimeter and the work area or operation in which it was worn.

e. The date the measurement was started.

*f. The time the measurement was started.

g. The time the measurement ended.

*h. The duration of the measurement.

*i. The settings of the dosimeter.

*j. The TWA of the measurement.

*k. The dose of the measurement.

4-7. Reviewing the Data

a. There is considerable potential for abuse resulting in invalid data. Employees have been known to whistle into the microphone, tap it, or place the dosimeter in a lunch box.

b. Many of the potential abuses can be detected by reviewing the time history (histogram on the Quest M-28D) of the dosimeter. A comparison with the periodic sound level measurements can uncover invalid data.

4-8. Determining the TWA of the Measurement

a. Usually, the measurement duration will be the entire work shift. In that case, the TWA value indicated by the dosimeter will be the actual TWA for the work shift.

b. When the measurement duration is not the entire work shift, then the TWA indicated by the dosimeter is not the TWA for the operation. This is because implicit in the indicated TWA is the assumption that the measurement duration is the entire work shift. The actual TWA for the work shift must be computed using procedures outlined in Appendix E.

c. The Department of Defense (DOD) Working Group on Hearing Conservation has standardized the format for noise dosimetry data. The working group requires that the TWA values for individual measurements be presented as whole numbers. Since most dosimeters read out in increments of 0.1 dB, rounding the numbers is required. Readings of 0.0 to 0.4 should be rounded to the next lower whole number and readings of 0.5 to 0.9 should be rounded to the next higher whole number.

4-9. Entry into the HHIM Database

For each individual TWA measurement, enter the TWA and other data into the HHIM database. Follow the instructions in the HHIM User's Guide. Enter the RAC after the TWA for the group has been determined.

CHAPTER 5: Determining the Group TWA

5-l. Estimating the Upper Tolerance Limit

a. Compute a one-sided upper tolerance limit (UTL) for the 90th percentile with a 75-percent confidence, based on the TWA measurements. A tolerance limit can be thought of as a confidence limit for a designated percentile of the parent distribution of individual measurements.

b. Dosimetry measurements of TWA usually have a normal distribution since the sound pressure is usually lognormal and decibels are logarithmic. Assuming normality will probably give good results. The UTL for a normally distributed variable can be estimated by calculating the mean and standard deviation for the sample values and by using the following formula:

$$\text{UTL} = \bar{x} + K \cdot s$$

Where:

UTL is the upper tolerance limit (in this case 90th percentile with 75 percent confidence)

$\bar{x}$ is the mean of the sample values

K is the one-sided tolerance limit for the normal distribution

s is the unbiased standard deviation of the sample values

The values of K are published for various percentiles and confidence levels. Appendix F shows examples of calculations and lists K values for the 90th percentile with 75-percent confidence.

c. It is recommended that any TWA values below 80 dBA be rounded to 80 before calculating the mean and standard deviation. We know that levels below 80 dBA contribute practically nothing to the accumulated noise exposure. However, values below 80 dBA unnecessarily add scatter to the results. Appendix F, paragraph F-2, illustrates the rationale for rounding values to 80 dBA.

5-2. Analyzing the Estimate

a. If the UTL is above 85 dBA and the individual TWA measurements are mostly above 85 dBA, then the value of the computed UTL is the TWA for the group of employees. Chapter 6 discusses procedures to be followed when the group TWA is above 85 dBA.

b. If the UTL is above 85 dBA but most of the individual measurements are below 85 dBA, and the ones over 85 dBA are close to 85 dBA, then more measurements will increase the statistical confidence and may result in a lower UTL. In such cases, 5 or 10 more measurements should be made. Appendix F discusses these steps. The additional measurements will produce better statistical accuracy and may preclude a borderline low exposure case from being overclassified as a hazard. If after the recomputation the UTL is still above 85 dBA, then proceed according to Chapter 6.

CHAPTER 6: Procedures for Handling a Group TWA 85 dBA or Higher

6-1. General

If the TWA for a group is 85 dBA or higher, then the operation is considered noise-hazardous, and the following steps should be initiated.

6-2. Enrollment in the Army Hearing Conservation Program

All members of the group must be enrolled in the U.S. Army Hearing Conservation Program.

a. Refer to DA PAM 40-501 for enrollment procedures and responsibilities.

b. Inform all employees working in noise-hazardous areas of the TWA to which they are exposed. The OSHA, DOD, and U.S. Army require this notification. A letter sent to the employees routed through the supervisory chain has been a convenient notification method. See Appendix G for an example of a notification letter.

6-3. Determining RACs for the Group

Use the TWA to determine the group RAC as outlined in Appendix H.

6-4. Entry into the HHIM Database

a. Up to this point, only individual TWA measurements have been entered.

b. For each individual TWA entry into the HHIM made per paragraph 4-9, enter the group RAC into the HHIM database. Follow the instructions in the HHIM Users Guide,

6-5. Entry into the Installation Noise Abatement Plan

Enter the noise-hazardous operation into the **installation** noise abatement plan. Include the TWA and RAC.

APPENDIX A - References

1. American National Standards Institute (ANSI) S1.4-1983 (ASA 47), Specification for Sound Level Meters.

2. ANSI S1.40-1984 (R1990), Specification for Acoustical Calibrators.

3. DA PAM 40-501, 27 August 1991, Hearing Conservation.

4. DODI 6055.12, 26 March 1991, DOD Hearing Conservation Program.

5. DODI 6055.1, 26 Oct 84, Occupational Safety and Health Program.

6. Title 29, Code of Federal Regulations (CFR), rev 1993, section 1910, part 95, Occupational Noise Exposure.

7. Lieberman, G.L., Tables for One-sided Statistical Tolerance Limits, Industrial Quality Control, Vol XIV, No. 10, April 1958.

APPENDIX B - Noise Hazard Criteria

B-l. Program Inclusion

Army personnel will be enrolled in the U.S. Army Hearing Conservation Program if they are routinely exposed to:

a. Steady-state noise having a TWA of 85 dBA or above. This criterion applies only to energy in the audible range, up to 16,000 Hz.

b. Impulse noise of 140 decibels, peak (dBP) or greater.

c. Airborne high frequency or ultrasonic noise, regardless of duration, in any of the one-third octave bands exceeding the corresponding value listed in Table B-l.

Table B-l. Airborne High Frequency or Ultrasonic Noise Limits.

One-third Octave Band Center Frequency (kHz)	One-third Octave Band Level (dB)
10	80
12.5	80
16	80
20	105
25	110
31.5	115
40	115
50	115

B-2. Hearing Protection

Regardless of the number of exposures or duration of exposure, personnel will wear approved hearing protectors whenever exposed to:

a. Steady-state noise having a sound level of 85 dBA or above or a TWA of **85 dBA** or above. This criterion applies only to energy in the audible range, up to 16,000 Hz.

b. Impulse noise of 140 dBP or greater.

c. Airborne high 'frequency or ultrasonic noise in any of the one-third octave bands exceeding the corresponding value listed in Table B-l.

B-3. Waiving of Hearing Protection Requirements

The requirement to wear hearing protectors may be waived if:

a. The sound energy is in the audible range, and

b. The TWA is well below 85 dBA, and

c. The uniform requirement to wear hearing protectors in an area does not enhance the hearing conservation program objectives. Refer to DA PAM 40-501 for more detailed waiver considerations.

APPENDIX C - Calculation of TWA Using Sound Level Measurements

C-1. Introduction

a. The TWA can be calculated using sound level data collected with an SLM. This method requires dividing the noise exposure into individual time periods over which the noise level is essentially constant.

b. This method is only practical in the rare situation in which the exposure consists of a small number of constant noise level exposure periods, or in production-type operations when the noise level is nearly constant for the entire work shift.

c. The wide availability of noise dosimeters in Army IH groups obviates the need to use this method.

C-2. Calculating the TWA

The TWA may be calculated from SLM measurements according to the following procedure:

a. Divide the noise exposure into individual time periods which represent essentially constant noise levels.

b. Calculate the dose using the following equation:

$$D = 100 \cdot \left(\frac{A_1}{T_1} + \frac{A_2}{T_2} + \ldots + \frac{A_i}{T_i}\right)$$

where: D = the noise dose expressed as percentage units (3 dB time-intensity exchange rate).

A_i = *the* total time of exposure (in minutes) at a particular noise level L_i

T_i = the limiting value (in minutes) for the particular noise level L_i

Table C-1 lists the limiting values T_i for any noise level L_i. Values of T for levels below 80 dBA may be disregarded (i.e., mathematically equivalent to an infinite limiting value T). Limiting values may also be calculated using the following equation:

$$T = \frac{480}{2^{\frac{L-85}{3}}}$$

where: T is the limiting time (in minutes)

L is the noise level (in dBA)

Table C-l. Limiting Values, *T*, for Various Values of Noise Level.

Noise Level (dBA)	Limiting Value of *T* (minutes)	Noise Level (dBA)	Limiting Value of *T* (minutes)
80	1524	100	15.0
81	1210	101	11.9
82	960	102	9.4
83	762	103	7.5
84	605	104	6.0
85	480	105	4.7
86	381	106	3.75
87	302	107	2.98
88	240	108	2.36
89	190	109	1.88
90	151	110	1.49
91	120	111	1.18
92	95	112	0.938
93	76	113	0.744
94	60	114	0.591
95	48	115	0.469
96	38	116	0,372
97	30	117	0.295
98	24	118	0.234
99	19	119	0.186
		120	0.148

NOTE: A 3 dB time-intensity exchange rate is implicit.

c. Calculate the TWA from the dose using the following equation:

$$TWA = 85 + 10 \cdot \log\left(\frac{D}{100}\right)$$

C-3. Example

If the daily noise environment at the operator position of an abrasive blaster is--

80 min at 87 dBA
150 min at 93 dBA
200 min at 97 dBA
50 min at 102 dBA

The dose calculation would be--

$$D = 100 \cdot \left(\frac{80}{302} + \frac{150}{76} + \frac{200}{30} + \frac{50}{9.4}\right)$$

$$D = 1422\%$$

The TWA calculation would be--

$$TWA = 85 + 10 \cdot \log\left(\frac{1422}{100}\right)$$

TWA = 96.5 dBA for the S-hour work shift

APPENDIX D - Dosimeter General Discussion

D-l. Requirements

Dosimeters used for measuring the noise exposure of Army personnel must--

a. Have the capability to integrate all sound levels from 80 dB to 130 dB, using a 3 dB time-intensity exchange rate, and measure dBA slow response. (Note that this differs from OSHA requirements which specify a 5 dB exchange rate and differs from the previous Army standard of 4 dB.)

b. Be calibrated only with an acoustical calibrator specified by the dosimeter manufacturer and meeting the requirements of ANSI S1.40.

D-2. Noise Dosimeters

a. Modem noise dosimeters simultaneously accumulate and display a variety of noise metrics and statistics. The quantities displayed, and the nomenclature for these quantities, vary among dosimeter manufacturers. There can be an alphabet soup of terms including TWA, Lavg, dose, projected dose, 8-hour dose, SEL, Leq, Lmax, Lmin, Lpk, Ldod, and more (see glossary for definitions).

b. Not all dosimeters display all these quantities, and the nomenclature is not standardized among dosimeters. It is important to keep these terms straight and understand the precise definition of these terms for each dosimeter used.

c. Most dosimeters have a capability to read out the maximum unweighted peak level (Lpk). A dosimeter reading of 140 dBP should be considered only a gross indication that an impulse hazard exists. The dosimeter does not have the required features to produce a valid impulse noise level reading for Army hearing criteria. However, the dosimeter will integrate the impulse noise into the TWA as required.

D-3. Army Mandatory Settings

A dosimeter used to measure the TWA for Army hearing conservation purposes must be set to the following:

a. A-weighting (dBA).

b. Slow response.

c. A time-intensity exchange rate of 3 dB.

d. A criterion level of 85 dBA.

e. A threshold level no higher than 80 dBA.

f. A minimum dynamic range of 80 to 130 dBA.

g. An upper limit of 115 dBA.

D-4. Other Settings

Dosimeters have a variety of other features depending on manufacturer and model. The use of these features in Army hearing conservation is optional, but these features may be of value to the hearing conservationist. The following brief discussion outlines some of the more common features available:

a. Computer interface. The two most common types are the data download and the upload/download.

(1) The data download allows electronic transfer of the accumulated logger data to a computer. The data can be stored in a memory file or printed by a computer printer.

(2) The upload/download allows data transfer, as above, as well as upload of commands to the dosimeter. The upload can be used for changing the settings on the dosimeter.

b. Printer interface. The dosimeter acts as a printer controller and allows the logged data to be printed by a computer printer. Both serial and parallel printer interfaces are available.

c. Time history and statistics logging. The dosimeter accumulates noise level statistics in addition to the TWA. These statistics can be useful in performing quality checks because any unusual or unexpected data time histories may be indicative of tampering with the measurement.

d. Graphing. Some dosimeters and associated computer software enable generation of the time histories and other statistical data in graphical format.

D-5. OSHA Settings

Occasionally it may be necessary to replicate the noise dosimetry in a manner identical to that used by OSHA. The OSHA uses two types of settings, depending on the purpose. One is for inclusion in the hearing conservation program and the other is for overexposure to noise. The two settings differ only in the threshold level; however, the settings are significantly different from the Army settings. The OSHA settings are:

a. A-weighting (dBA).

b. Slow response.

c. A time-intensity exchange rate of 5 dB.

d. A criterion level of 90 dBA.

e. A threshold level of 80 dBA for inclusion or 90 dBA for overexposure.

f. A minimum dynamic range of 80 to 130 dBA.

g. An upper limit of 115 dBA.

APPENDIX E - TWA and Varying Measurement Durations

El. Introduction

a. The measurement duration is the length of time the employee wears the dosimeter. The dosimeter reads out the TWA, the noise dose and the Leq, and provides a projection of noise dose to an 8-hour duration. However, the TWA value indicated on the dosimeter is not the TWA for the work shift when the duration of the measurement is not equal to the duration of the entire work shift. This is because implicit in the TWA is an 8-hour duration. This appendix illustrates typical TWA results and provides methods for calculating the TWA for the work shift if the measurement duration is not equal to the work shift duration.

b. In the following discussion, quantities in quotation marks (" ") refer to the value for the reading as displayed on the Quest M-28D printout. On this printout, the labels are in capital letters so that dose is labeled "DOSE", etc.

E2. An 8-Hour Work Shift Measured for the Entire S-Hour Work Shift

a. Here, the work shift is 8 hours and the employee wears the dosimeter for 8 hours. The results are straightforward.

b. The "DOSE" is the noise dose accumulated over the measurement duration, which in this case is the entire 8-hour work shift. Because of the 8-hour measurement duration, the "DOSE" and the "8hr DOSE" are numerically equal.

c. The "LEQ" is the average sound level over the measurement duration. Since the work shift is 8 hours long and the measurement duration is 8 hours, the "LEQ" is numerically equal to the "TWA" and both are considered the TWA for the work shift.

d. Example:

The dosimeter printout might show:

"RUN TIME----8:00:00"
"LEQ----91.0dB TWA----91.0dB DOSE-400 % 8hr DOSE--400 % "

The TWA reported for the work shift would be:

TWA = 91 dBA for the 8-hour work shift

E-3. An S-Hour Work Shift Measured for Less than 8 Hours

a. Here, the work shift is 8 hours but the employee wears the dosimeter for a shorter time (the measurement duration is less than 8 hours). This is appropriate for making a quick estimate of the TWA in situations where the noise environment is relatively constant over time.

b. The "DOSE" is the noise dose accumulated over the measurement duration, which in this case is less than the 8-hour shift. The "8hr DOSE" is the dose that would be sustained by the wearer if the dosimeter was worn for 8 hours.

c. The "LEQ" is the average sound level over the measurement duration. The "TWA" is the TWA that would exist if the work shift was only as long as the measurement duration and all noise exposure stopped after the end of measurement. Since exposure does not stop and the work shift is 8 hours long, the TWA after 8 hours of exposure will be numerically equal to the "LEQ" for the measurement duration. The TWA for the entire work shift will be greater than the "TWA" indicated on the dosimeter for the shorter measurement duration.

d. Example:

The dosimeter printout might show:

"RUN TIME----2:00:00"
"LEQ----88.0dB TWA----82.0dB DOSE----50 % 8hr DOSE--200 % "

The TWA reported for the entire work shift would be:

TWA = 88 dBA

E-4. A Work Shift Greater than 8 Hours Measured for the Entire Work Shift

a. The "DOSE" is the noise dose accumulated over the measurement duration which in this case is more than 8 hours. The "DOSE" is greater than the "8hr DOSE".

b. Since the work shift is more than 8 hours long and the measurement is made for the entire work shift, the "TWA" is the TWA for the actual work shift. The "LEQ" is the average sound level over the measurement duration. The "TWA" is greater than the "LEQ" .

c. Example:

The dosimeter printout might show:

"RUN TIME----16:00:00"
"LEQ---91 .0dB TWA----94.0dB DOSE----800 % 8hr DOSE--400 % "

The TWA reported for the work shift would be:

TWA = 94 dBA for the lo-hour work shift.

ES. A Work Shift Greater than 8 Hours Measured for Less than the Entire Work Shift

a. This is appropriate for making a quick estimate of the TWA where the noise environment is constant over time. In this case, there is no convenient numerical equality between the TWA and any of the dosimeter readings. The TWA must be calculated manually. Note that the measurement duration may be more than 8 hours, or less than 8 hours, or even equal to 8 hours.

b. First, estimate the dose for the entire work shift. This is done by multiplying the dose measured during the measurement duration by the ratio of the work shift duration to the measurement duration. This is valid because the noise environment is relatively constant over time. If the noise environment was not constant over time, it would be necessary to measure over the entire work shift and a short measurement duration would not be used.

c. Then calculate the TWA from the estimated dose for the actual work shift duration.

d. Example: The XYZ Army Depot is on a lo-hour work shift. The launcher rework hue has a relatively constant rate of noise dose accumulation so that a 4-hour measurement duration was chosen.

The dosimeter printout showed:

"RUN TIME---4:00:00"
"LEQ---91.0dB TWA--88. 0dB DOSE--200 % 8hr DOSE---400 % "

The estimated lo-hour dose was:

$$D = \frac{\text{“DOSE”} \cdot \text{WORK SHIFT DURATION IN HOURS}}{\text{“RUN TIME” IN HOURS}}$$

$$D = \frac{\mathbf{200} \cdot 10}{4}$$

$= 500$ percent for the lo-hour work shift

The TWA for the lo-hour work shift is:

$$\text{TWA} = 85 + \mathbf{10} \cdot \log(\frac{D}{100})$$

$$= \mathbf{85} + 10 \cdot \log(\frac{500}{100})$$

$$= 92.0$$

The TWA reported for the work shift would be:

TWA = 92 **dBA** for the lo-hour work shift

E6. A Work Shift Less than 8 Hours Measured for the Entire Work Shift

a. This is similar to other cases in which the measurement duration is the entire work shift.

b. The “DOSE” is the noise dose accumulated over the measurement duration, which in this case is less than 8 hours but is for the entire work shift. The "8hr DOSE” is the dose that would be sustained if the work shift was 8 hours; however, the work shift is less than 8 hours, so the "8hr DOSE” is superfluous information.

c. The “LEQ” is the average sound level over the measurement duration which is the entire work shift. The measurement was for the entire work shift, and the indicated “TWA” is the actual TWA.

d. Example: The XYZ &my Depot is on a lo-hour work shift but has instituted a job sharing program. Two employees share a job on the launcher rework line so that each employee works 5 hours per day (a 5-hour work shift).

The dosimeter printout for one of the employees showed:

"RUN TIME---5:00:00"
"LEQ---91.0dB TWA---89.0dB DOSE---250 % 8hr DOSE---400 %"

The TWA reported for the work shift would be:

TWA = 89 dBA for the 5-hour work shift

E7. A Work Shift Less than 8 Hours Measured for Less than the Entire Work Shift

a. Again, there is no convenient numerical equality between the TWA and any of the dosimeter readings. The TWA must be calculated manually.

b. Estimate the dose for the entire work shift from the "DOSE" measured during the measurement duration by using the ratio of the work shift duration to the measurement duration. The "LEQ" and "8hr DOSE" are superfluous information.

c. Then calculate the TWA from the estimated dose for the actual work shift duration.

d. Example: The XYZ Army Depot is on a lo-hour work shift but has instituted a job-sharing program. Two employees share a job on the launcher rework line so that each employee works a 5-hour work shift. Because of the relatively constant rate of noise dose accumulation, a 2-hour measurement duration was chosen.

The dosimeter printout showed:

"RUN TIME---2:00:00"
"LEQ----91.0dB TWA---85.0dB DOSE---100 % 8hr DOSE---400 %"

The estimated 5-hour dose is:

$$D = \frac{\text{"DOSE"} \cdot \text{WORK SHIFT DURATION IN HOURS}}{\text{"RUN TIME" IN HOURS}}$$

$$D = \frac{loo \cdot 5}{2}$$

= 250 percent for the 5-hour work shift

The TWA for the 5-hour work shift is:

$$TWA = 85 + 10 \cdot \log(\frac{D}{100})$$

$$= 85 + 10 \cdot \log(\$)$$

$$= 89.0$$

The TWA reported for the work shift would be:

TWA = 89 dBA for the 5-hour work shift

APPENDIX F: Statistical Analysis of Exposure Measurement Sample Results

F-l. Calculating the UTL

a. Formulas for UTL, mean and standard deviation are:

$$\text{UTL} = \bar{x} + K \cdot s$$

Where:

UTL is the upper tolerance limit (in this case 90th percentile with 75 percent confidence)

$\bar{x}$ is the mean of the sample values

s is the unbiased standard deviation of the sample values

K is the one-sided tolerance limit for the normal distribution and is listed in Table F-l.

Table F-l. *K* Factors for One-Sided Tolerance Limits of a Normal Distribution

Number of Measurements	*K* Factor for 90th Percentile with 75 percent Confidence
3	2.501
4	2.134
5	1.961
6	1.860
7	1.791
8	1.740
9	1.702
10	1.671
11	1.646
12	1.624
13	1.606
14	1.591
15	1.577
16	1.566
17	1.554
18	1.544
19	1.536
20	1.528

(Lieberman, reference 7)

$$\bar{x} = \frac{\Sigma x_i}{n}$$

Where:

x_i is the TWA of the *i*th sample

n is the number of samples

$$s = \sqrt{\frac{\Sigma x_i^2 - \frac{(\Sigma x_i)^2}{n}}{n - l}}$$

Here, s is the unbiased standard deviation.

b. While the individual measurements of TWA are rounded off to the nearest decibel, the calculated values of the mean and standard deviation should be carried out to at least two decimal places. This is because rounding off prematurely could cause severe inaccuracies. (Note: Most hand-held calculators or computer software packages will compute the mean and standard deviation. Caution: Functions supplied with LOTUS 1-2-3® software will not calculate an unbiased standard deviation.)

c. Example: The TWAs for each of five employees testing engines were measured for 8 hours, the length of their work shift. The measured TWA values were 79.1, 88.5, 86.9, 91.5, and 90.5 dBA. After rounding the individual measurements to the nearest dB and up to 80 dBA, the values became 80, 89, 87, 92, and 91. From Table F-l, the value of K for a sample size of 5 is 1.961.

$$\bar{x} = \frac{\Sigma x_i}{n}$$

$$= \frac{80 + 89 + 87 + 92 + 91}{5} = \frac{439}{5}$$

$$= 87.80 \text{ dBA}$$

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$$s = \sqrt{\frac{\Sigma x_i^2 - \frac{(\Sigma x_i)^2}{n}}{n - 1}}$$

$$= \sqrt{\frac{80^2 + 89^2 + 87^2 + 92^2 + 91^2 - \text{—}439^2}{5 - 1}}$$

$$= 4.76 \text{ dBA}$$

$$\text{UTL} = \bar{x} + K \cdot s$$

$$\text{UTL} = 87.8 + (1.961 \cdot 4.76)$$

$$= 97.1 \text{ dBA}$$

Since most of the TWA values were above 85 dBA and the UTL was also above 85 dBA, we can be quite sure that the 90th percentile TWA of the exposures for this group was above 85 dBA. The group is considered exposed to hazardous noise and the group TWA is 97 dBA.

F-2. Borderline TWA Exposures

a. When TWA measurements are above 85 dBA, it is easy to decide whether or not the group belongs in a hearing conservation program. The decision becomes more difficult when most of the TWA measurements and the mean are below 85 dBA. The following examples illustrate this situation and the 80 dBA rounding procedure is recommended to assist in making the decision.

b. Example: The TWAs for each of five employees in the control rooms were measured for their 8-hour work shift. The measured TWA values were 74, 82, 84, 83, and 74 dBA. Without 80 dBA rounding:

$$\bar{x} = \frac{74 + 82 + 84 + 83 + 74}{5} = \frac{397}{5}$$

$$= 79.40 \text{ dBA}$$

$$s = \sqrt{\frac{74^2 + 82^2 + 84^2 + 83^2 + 74^2 - \frac{397^2}{5}}{5 - 1}}$$

$$= 4.98 \text{ dBA}$$

$$\text{UTL} = \bar{x} + K \cdot s$$

$$= 79.40 + (1.961 \cdot 4.98)$$

$$= 89.2 \text{ dBA}$$

c. In the above example, all the TWA values were below 85 dBA, and the mean value of the TWAs was below SO dBA, but the UTL was 89 dBA, which would put this operation in the hazard category. In this case, taking more measurements will increase statistical confidence. This would be reflected in the calculations as a reduced value of K and would lead to a lower value for UTL. Accordingly, take 10 more measurements which would be 78, 83, 83, 74, 84, 84, 81, 73, 74, and 76 dBA. There is now a total of 15 measurements. Calculate the mean to be 79.13 and the standard deviation to be 4.49. For a sample size of 15, the value of K from Table F-l, is 1.577. Again, without 80 dBA rounding:

$$\text{UTL} = \bar{x} + K \cdot s$$

$$= 79.13 + (1.577 \cdot 4\text{-}49)$$

$$= 86.2 \text{ dBA}$$

The UTL is now 3 dB lower than it was for the sample of 5, but it is still greater than 85 dBA. On a purely statistical basis, there is a 75-percent confidence that the 90th percentile of the TWA values is no higher than 86.2 dBA. However, there is a troubling aspect to this procedure. We have measured the TWA for 15 employees and they are all exposed to less than 85 dBA. Yet the statistics tell us to put them and their entire group in the hearing conservation program.

d. The estimate for the 90th percentile is heavily dependent on the standard deviation, which in turn is large if the scatter of the sample values is large. One of the factors causing a large scatter in our example is the presence of low TWA values such as 73 dBA. Levels below 80 dBA contribute practically nothing to the accumulated noise exposure. These levels do not even have to be counted toward the TWA. There would be no change in the total noise exposure if all the values of TWA below 80 dBA were actually 80 dBA. However, there would be a change in the statistics. The 15 TWA values for the preceding example would be 80, 82, 84, 83, 80, 80, 83, 83, 80, 84, 84, 81, 80, 80, and 80 dBA. The mean is now 81.60 and the standard deviation is 1.72.

$$\mathbf{UTL} = \bar{x} + K \cdot s$$

$$= 81.60 + (1.577 \,.\, 1.72)$$

$$= 84.3 \text{ dBA}$$

The group TWA would be reported as 84 dBA.

Increasing the very low values of TWA to the threshold value of 80 dBA increases the mean but reduces the data scatter and therefore the UTL. Use of this procedure, loses statistical purity but provides some rational basis for not enrolling in the hearing conservation program those groups who appear to have little likelihood of sustaining exposures of 85 dBA or above.

APPENDIX G - Sample Notification Letter

MEMORANDUM FOR (Employee)

SUBJECT: Employee Notification of Sampling Results - Noise Surveys Warehouse Areas

1. DA regulations require employees be notified of their exposure results from Industrial Hygiene surveys. The following results are from noise surveys performed in Building #___________, Section_________ on (DATE).

EMPLOYEE	NOISE EXPOSURE, Time Weighted Average (TWA) dBA
Joe Doaks	87 dBA

2. Statistical calculations of the (GROUP) employees' exposures indicate levels are above the OSHA noise standard (29 CFR 1910.95) of 85 dBA for a significant number of days during the year. Therefore, these employees are included in the (INSTALLATION) Hearing Conservation Program.

3. According to the noise survey performed, you are required by the DA's Hearing Conservation Policy, DA PAM 40-501, to:

a. Wear either earplugs or noise muffs whenever noise levels are greater than or equal to 85 dBA.

b. Be enrolled in the (INSTALLATION) Hearing Conservation Program.

c. Obey warning signs throughout the installation in noise hazardous areas and on equipment which require personnel to wear hearing protection.

4. If you have any questions regarding this matter contact the Industrial Hygiene Office at extension (PHONE NO.).

JOHN R. DOE
Industrial Hygienist
Fort Smith Health Clinic

CF:
Employee File
Supervisor

APPENDIX H - Determining RACs for Noise Hazards

H-l. Procedures for Determining a RAC

Risk assessment codes (RACs) are assigned to hazardous operations to help quantify risks to personnel and to aid in the establishment of funding priorities for corrective actions. The following, adapted from DODI 6055.1, outlines the procedure for determining the RAC for a noise hazard:

a. Determine the health hazard severity category (HHSC). The HHSC reflects the magnitude of exposure to noise and the medical effects of exposure.

(1) Assign exposure points (EP)--a maximum of eight arc possible-- using different equations for steady-state or impulse noise. If exposure to steady-state and impulse noise occurs on the same day, or even simultaneously, use the greater of the points calculated for either exposure. Do not combine points for both exposures.

(a) For steady-state noise, convert the TWA to dose using the following equation:

$$D = \mathbf{loo} \cdot 10^{\frac{TWA - 85}{10}}$$

where:

D is the percent noise dose (a TWA of 85 dBA is 100 percent dose)

TWA is the S-hour time weighted average noise exposure in dBA

Then:

$$EP = \frac{D}{100}$$

(b) For impulse noise:

$$EP = \frac{N}{100} \cdot 10^{\frac{Lpk - 138}{5}}$$

where:

N is the number of impulse noise events per day

Lpk is the peak noise level of the impulse in dBP

(2) Assign six medical effects points (MEP) because the medical effect is permanent hearing loss.

(3) Find the sum of EP and MEP and determine the HHSC using Table H-l. Note that the total will be no higher than 14 points.

Table H-l. Health Hazard Severity Category

Total Points (EP + MEP)	HHSC
7-14	II
<7	III

b. Determine the mishap probability category (MPC). The MPC reflects the probability of mishap and the number of personnel exposed to noise in the operation being assessed.

(1) Assign points for the consistency of exposure using Table H-2.

Table H-2. Consistency of Exposure Points

Long-Term Consistency	Weekly Consistency 1 Day/Week	2-4 Days/Week	5 Days/Week
Not every week	2	5	8
Every week	3	6	8

(2) Assign points for the number of employees exposed to the operation using Table H-3.

Table H-3. Employee Number Points

Number of Exposed Personnel	**Points**
<5	2
5-9	3-4
10-49	5-6
>49	7-8

(3) Find the sum of the points for consistency of exposure and the points for the number of personnel exposed. Determine the MPC using Table H-4.

Table H-4. Mishap Probability Category

Total Points (Consistency + Number of Personnel)	MPC
14-16	A
10-13	B
5-9	c
<5	D

c. Determine the RAC using Table H-5.

Table H-5. Risk Assessment Codes

	MPC			
HHSC	A	B	C	D
I.	RAC 1	RAC 1	RAC 2	RAC 3
II	RAC 1	RAc2	RAC 3	RAC 4
III	RAc2	RAc3	RAC 4	RAc5
Iv	RAc3	RAc4	RAC 5	RAc5

H-2. RACs and Hearing-Protection Devices

Assigning a RAC reflects the extent and severity of a noise hazard based solely on an analysis of the noise environment. It does not reflect the effects of any hearing protection worn by the employees. The RACs do not account for hearing-protection devices because engineering controls and other means should be used to control noise exposures. Hearing protection should be considered only as a last resort or until engineering controls are implemented.

H-3. Examples of Determining RACs for Noise Hazards

a. A Steady-State Noise Hazard. The dynamometer section of the engine repair facility at XYZ Army Depot employs 7 mechanics and has an average weekly output of 28 engines. The work shift is 10 hours per day, 4 days per week. Dosimetry measurements have determined that the TWA for the mechanics is 96 dBA.

(1) Convert the TWA to percent dose (or use dose readings from the dosimeters):

$$D = 100 \cdot 10^{\frac{TWA - 85}{10}}$$

$$D = 100 \cdot 10^{\frac{96 - a5}{10}}$$

$$D = 100 \cdot 10^{1.1}$$

$$D = 1259 \text{ percent}$$

(2) Determine the EP:

$$EP = \frac{D}{100}$$

$$EP = \frac{1259}{100}$$

EP = 12.59 therefore, use EP = 8 points

(3) Assign six points to MEP.

(4) Determine the HHSC using Table H-l.

$$MEP + EP = 8 + 6$$

$$= 14 \text{ points}$$

Therefore, the HHSC is II.

(5) Determine the MPC. Since this exposure occurs 4 times per week every week, 6 consistency points are assigned according to Table H-2. There are 7 employees exposed, and therefore, 4 points are assigned for this quantity according to Table H-3. The sum of these points is 10. Therefore, the MPC is B per Table H-4.

(6) Determine the RAC. For a IIB exposure, the RAC is 2 according to Table H-5.

b. An Impulse Noise Hazard. The drop forge operations at XYZ Army Depot involve 56 employees working 8 hours per day, 40 hours per week. The typical drop forge produces an impulse noise level of 151 dBP at an average rate of 50 impulses per minute, 24,000 impulses per day.

(1) Determine the EP value:

$$EP = \frac{N}{100} \cdot 10^{\frac{Lpk-138}{5}}$$

$$EP = \frac{24000}{100} \cdot 10^{\frac{151-138}{5}}$$

$$= 240 \cdot 10^{2.6}$$

$$= 95{,}546$$

However, EP = 8 (since 8 is the maximum value of EP)

(2) Determine the HHSC:

MEP + EP

6 + 8 = 14 points

Therefore, the HHSC is II according to Table H-l.

(3) Determine the MPC: Since the exposures occur 5 days per week, every week, 8 consistency points are assigned according to Table H-2. There are 56 employees exposed, and therefore, 8 points are assigned for this quantity according to Table H-3. The sum of these points is 16. Therefore, the MPC is A according to Table H-4.

(4) Determine the RAC: For a IIA exposure the RAC is 1 according to Table H-5.

GLOSSARY

AMEDD
Army Medical Department

ANSI
American National Standards Institute

area noise monitoring
Measuring the TWA not on a person but at a fixed location in a room occupied by the employee group of interest. Appropriate only if the noise level is relatively constant over the range of travel of the employees.

average sound level (Lavg)
The time average of the varying sound level using a prescribed time-intensity exchange rate.

CFR
Code of Federal Regulations

criterion level
Sound level corresponding to 100 percent noise dose. The Army uses an 85 dBA criterion level.

D
Noise dose in percent

DA PAM
Department of the Army Pamphlet

dB
Decibel

dBA
Decibels, A-weighted

dBP
Decibels, peak, also peak pressure level, no frequency weighting. Usually used to quantify the magnitude of an impulse noise event.

DOD
Department of Defense

DODI
Department of Defense Instruction

dosimetry
Personal noise dosimetry

eight-hour dose
Projected dose for an 8-hour work shift (see projected dose).

eight-hour time-weighted average sound level (TWA)
The constant noise level, measured in dBA, which can potentially produce the same hearing damage over an 8-hour period as the actual workday noise exposure.

exchange rate
Time-intensity exchange rate

exposure points
Numerical valuation of the severity of exposure to a health hazard. Used in estimating RACS.

health hazard severity category (HHSC)
Characterization of the magnitude of exposure to noise and the medical effects of exposure. Used in estimating RACs.

HHIM
Health Hazard Information Module

HHSC
Health hazard severity category

Hz
Hertz

IH
Industrial hygiene

impulse noise
Singular noise pulses, each less than 1 second in duration, or repetitive noise pulses occurring at greater than l-second 'intervals.

Lavg
Average sound level

LCD
Liquid crystal display (on the dosimeter)

Ldn
A descriptor used in qualifying the noise level used in environmental noise studies. It is a feature of the Quest M-28D that is not used for hearing conservation purposes and is turned off.

Ldod
Average sound level (Lavg) using a 4 dB time-intensity exchange rate. No longer used for Army hearing conservation.

Leq
Equivalent sound level. Leq is commonly used as the abbreviation for the average sound level using energy averaging (numerically equal to a 3 dB exchange rate). The term has also been used generically as Lavg.

Lmax
Maximum sound pressure level occurring within a specified time. The frequency weighting and averaging time for Lmax is as set on the dosimeter. For Army and OSHA, this would be A-weighting, slow response.

Lmin
Minimum sound pressure level occurring within a specified time. The frequency weighting and averaging time for Lrnin is as set on the dosimeter. For Army and OSHA, this would be A-weighting, slow response.

Lpk
Greatest instantaneous pressure level (dBP) occurring within a specified time. No frequency weighting and the shortest rise time capability of the instrument is used.

log
Common logarithm (base = 10)

mean
Sum of all observations divided by the number of observations.

MEDDAC
U.S . Army Medical Department Activity

medical effects points (MEP)
Numerical valuation of the medical effects of a hazard. Used in estimating RACs.

MEP
Medical effects points

mishap probability category (MPC)
Characterization of the probability of mishap and the number of personnel exposed to noise in the operation being assessed. Used in estimating RACs.

noise dose (*D*)
The ratio, expressed as a percentage, of the damage potential of a noise environment to the damage potential of exposure to 85 dBA for 8 hours. Implicit in the noise dose concept is a specified time-intensity tradeoff rate which is 3 dB in this guide.

octave band
A division of the audible range of frequencies into subgroups such that in each division the upper frequency limit is twice the lower limit.

OHMIS
Occupational Health Management Information System

OSH
Occupational Safety and Health

OSHA
Occupational Safety and Health Administration (U. S . Department of Labor)

personal noise dosimetry
Measuring the noise exposure of a person by attaching a noise dosimeter to the person's collar and running it while the person is performing work duties.

projected dose
An estimate of the noise dose for a longer duration based on measurements made only for a shorter duration.

RAC
Risk assessment code

SEL
Sound exposure level. The concept is similar to TWA except the accumulated dose is spread over 1 second instead of 8 hours. SEL is used in community noise studies as a measure of noise pollution.

SLM
Sound level meter

steady-state noise
Continuous noise or noise that consist of impulses spaced less than 1 second apart.

threshold level
Sound level below which the dosimeter accumulates no dose.

time-intensity exchange rate
The change in the level of sound required to double the damage potential of the sound during a fixed time period of exposure.

TWA
8-hour time-weighted average sound level

UTL
Upper tolerance limit for the normal distribution.

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